1 Active Galactic Nuclei II + III

1) Explain as fully as you can how our understanding of AGN would improve if we could obtain data in the unobservable EUV band.

2) The figure below shows the Fe-K line profile in the nearby Seyfert galaxy NGC 4151. If such a line is formed in an accretion disk rotating about a black hole, gravitational redshifts dominate if the disk is seen face-on, but Doppler shifts dominate if the disk is seen more edge-on. In the latter case, there are large blueshifts due to rotating matter approaching the observer (in addition to the Doppler and gravitational redshifts).

a) By inspection of the above Fe-K line profile in NGC 4151, what is the likely orientation of the accretion disk?

b) Assuming that the peak of the line is at the rest-energy, estimate the largest ratio of observed-energy to rest-energy of the line photons, $E_{\rm obs}/E_0$.

c) Hence estimate the closest proximity of the line-emitting matter to a central Schwarzschild black hole, in units of r_g, the gravitational radius. This radius is smaller than $6r_g$. Why might this be a problem?

d) How might rotation of (a) the disk and (b) the black hole alleviate the above 'problem'?

e) In an X-ray observation lasting 10^5 seconds evidence was found that the line-shape changes in response to variations in the X-ray continuum. However it could not be ascertained what the precise response time was. Assuming the accretion disk does not extend closer to the black hole than the last stable orbit, compute upper limits to the black-hole mass for the two cases of (a) Schwarzschild black hole, and (b) maximally rotating Kerr black hole.

NOTE: The gravitational redshift formula for a Schwarzschild black hole is $E_{\rm observed} = E_{\rm emitted}\sqrt{[1-(2r_g/r)]}$ and $r_g = 1.48 \times 10^{13} M_8$ cm where $M_8 = 10^8 M_\odot$.

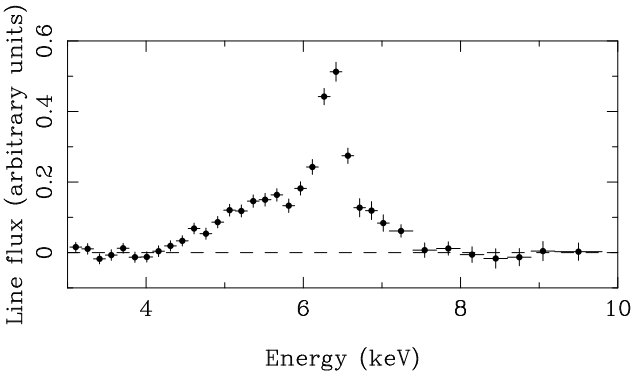

Figure 1: Fe Line Profile in the nearby Seyfert galaxy NGC 4151